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THE APPLICATION OF VIRTUAL INTENSIVE CARE UNIT PRINCIPLES IN THE AEROMEDICAL EVACUATION ENVIRONMENT CAN IMPROVE PATIENT SAFETY, LEAD TO BETTER PATIENT OUTCOMES AND DELIVER INTEGRATED MEDICAL CARE

by

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Biography

Lieutenant Colonel Beatrice Dolihite is assigned to Air War College, Air University, Maxwell AFB, AL. Lt Col Dolihite graduated in 1995 from Samford University in Birmingham, Alabama and received her commission into the Air Force through the Reserve Officers' Training Corps. She currently holds a Bachelor of Science in Nursing, Master of Public Administration and a Master of Military Operational Art and Science. She holds a certification in medical-surgical nursing from the American Nurses Credentialing Center. She deployed as a Critical Care Air Transport Team (CCATT) member and appeared in the 2009 Warrior Care Documentary Campaign. Lt Col Dolihite has experience in emergency room and outpatient clinic arenas. She is a member of the American Nurses Association, American Organization of Nurse Executives and the Alabama State Nurses Association.

Abstract

Military Health Service (MHS) professionals deliver care in unique, austere, joint operational environments. The complexity and unpredictability of future environments requires continuous development and enhancement of joint medical capabilities. A primary joint medical capability of health service support is en route care.[1] Management of casualties takes place through the joint en route casualty care system (ERCCS). The aeromedical evacuation (AE) platform is a primary source of patient movement through the ERCCS. Casualty management of critically ill and wounded in AE settings is complex but essential in saving lives. The application of virtual intensive care unit (vICU) principles in AE settings can improve patient safety, lead to better patient outcomes and deliver integrated medical care. This paper provides a historical narrative of telemedicine and vICU principles and highlights the utility of this capability in the AE environment. Utilizing current civilian and Department of Defense (DoD) vICU research, an analysis of the principles demonstrates significant potential implications on patient safety, outcomes and resources. Recommendations are to fund, research and define vICU capability as an AE requirement and establish a Joint vICU Command Center as the first step to implementation.

Introduction

The increasing unpredictability and complexity of the global environment drives the US military to innovate and develop capabilities to protect national security interests.[2] Medical research and innovation are critical to support the human weapon system in volatile, uncertain, complex and ambiguous (VUCA) environments. The MHS supports the warfighter and operational mission by fostering, protecting, sustaining, and restoring health and through utilization of casualty management capabilities.[3] The warfighter in a non-garrison environment is at risk for sustaining life-threatening battle injuries requiring immediate care. MHS professionals must deliver care in unique, austere, joint operational environments and treat patients at all levels through the ERCCS, moving patients from point of injury to the next level of care without compromising patient condition.[4] While AE is a primary platform used for patient transport in the ERCCS and has saved thousands of lives, the proven benefits of AE demand development and enhancement for future conflicts.

AE provided a safe, effective platform to move patients to the next level of care during the last 14 years of combat. In a recent interview, former Air Force Surgeon General, Lieutenant General Thomas Travis stated, "We have completed over 194,000 patient movements since 9/11, including transporting 7,900 critical care patients…Our 'care in the air team' capability has been instrumental in advancing our practice of transporting only stable patients to a paradigm of en-route patient treatment that has become integral to health service support in joint doctrine…we have executed joint en-route care that is historic in achieving unprecedented survival rates."[5] US air superiority has made it possible for AE to be successful. However, in planning for future contested operational environments, innovative critical care AE delivery systems must be developed and implemented. In response to the 2015 National Security Strategy (NSS) rebalance to Asia and the Pacific and the 2015 National Military Strategy focus on future anti-access and anti-denial (A2/AD) environments, the Air Force Medical Service (AFMS) recently published the Medical Operations in Denied Environments (MODE) concept which advocates for vICU AE capability.[6] [7]

MODE is a conceptual framework directed at development of future capabilities to counter challenges of delivering care to the warfighter in an A2/AD environment.[8] MODE highlights vICU capability to project advanced care to forward medics and caregivers. The MODE concept recognizes vICU capability as a force multipler as stated, "Due to the high probability of our medical personnel being overwhelmed or not having the skill sets to treat patients within a contested environment, virtual augmentation can serve as a force multiplier on the ground and in the air."[9] The AE system must be capable of moving casualties using integrated medical teams.[10] The application of vICU principles in the AE setting will create a more robust comprehensive medical team model to meet this requirement. Current ongoing efforts to expand medical capabilities such as telemedicine, specificially vICU, in the transport environment exist today.[11] Implementation of evidence-based vICU principles in AE environments is crucial to meet demands in future operations.

The application of vICU principles in AE settings has the potential to improve patient safety, lead to better patient outcomes and deliver integrated medical care. This paper will provide a historical narrative of telemedicine and vICU principles. Utilizing current civilian and DoD vICU research, an analysis of the principles will be provided to demonstrate the impact on patient safety, outcomes and resources. The analysis will then highlight utility of the principles in AE environments and recommend development of a vICU AE requirement and establishment of a joint vICU command center.

Thesis

This research paper uses a qualitative approach to demonstrate how the utility of vICU principles in an AE setting can improve patient safety, lead to better patient outcomes and deliver integrated medical care and makes recommendation to implement such a system in support of the ERCCS.

History of Telemedicine and DoD Applications

Telemedicine is "the use of medical information exchanged from one site to another via electronic communications to improve a patient's clinical health status."[12] The use of telemedicine dates back to the 1950s when NASA first introduced it in the manned space-flight program. A requirement emerged to continuously monitor astronauts exposed to abnormal physiological conditions which led to the development of telemedicine capabilities. The creation of such a system provided a means of diagnosing and treating in-flight emergencies.[13]

Telemedicine is widely used throughout the medical community today because it provides a means to extend care into more remote locations and it is an efficient way to utilize limited resources.[14] Telemedicine capabilities emerged as remote technologies to support clinical decision making, immediate intervention and provide continuous monitoring and standardization in patient management.[15] The delivery of care through telemedicine modalities addresses several needs to include an aging population with increased needs for critical care services and shortages in critical care physicians.[16] Telemedicine brings more capability to the military medical service allowing care to be projected and delivered all over the world.

The MHS successfully utilizes telemedicine in many areas throughout the DoD. For example, the Air Force has a robust tele-radiology platform proven beneficial in all operational environments because it mitigates the need to have a full time radiologist on site and provides the required level of expertise needed to treat patients. The Army utilizes telemedicine to treat patients with PTSD on the battlefield. Telemedicine provides the Army with capability to extend limited mental health resources to operational environments and enhance care.[17] The Navy Medical Center in San Diego currently uses telemedicine to support its tele-critical care program where it provides monitoring of critically ill patients at Naval Hospital Camp Pendleton. The program has identified patients with deteriorating conditions and increased the use of standard protocols and best practices. The Navy's implementation of vICU improved patient outcomes while bridging the gap of constrained personnel assets.[18] Telemedicine is a capability the MHS must continue to leverage and enhance because it maximizes scare resources and prepares for future operational environments.

History of vICU

In collaboration with NASA, the company Spacelabs Medical, Inc became the pioneer of medical telemetry and was instrumental in monitoring health of astronauts in space. In the mid-1960s, Spacelabs Medical transitioned from monitoring in space to monitoring in hospitals. In 1974, the company launched the first-ever patient-monitoring system for intensive care units which is the standard of care today.[19] vICUs have grown in number significantly over the years with more than 40 programs in existence today, reaching more than 250 hospitals and more than 10% of ICU patients in the country.[20] The vICU concept includes a centralized care team linked to the bedside ICU team and patient via advanced audiovisual communication and computer systems. The centralized care team is composed of seasoned critical care nurses, support staff and intensivists.[21] vICUs bring together technology and expertise to provide surveillance and support for a large number of ICU patients in many different geographical locations.[22] vICUs allow clinicians access to real-time data through continuous monitoring of the patient giving them the ability to immediately identify life-threatening physiological changes. vICU staff direct communication with the bedside staff and patient to facilitate plans of care. The evolution of vICU demonstrates benefits to patient safety, outcomes and expansion of limited resources to deliver high-quality and cost-effective health care.[23] [24] The desired care environment for critically ill patients is a non-distracting, quiet setting which reduces potential for medical errors and patient harm. Patient safety in the AE setting requires continuous efforts to mitigate distractions and ensure zero harm to patients. The execution of vICU principles could provide another level of safety to AE environments.

Improve Patient Safety

Calming a Tumultuous Environment

Delivering care in the back of a military aircraft is vastly different than in a controlled hospital environment. Delivery of care to multiple patients of varying acuities in a confined space, multitasking, time urgency, long duty hours, complex handoffs, limited resources, and multiple stressors of flight contribute to the complexity.[25] Safety concerns in the AE system are uniquely complex and warrant further research and development of processes to mitigate issues.[26] AE and Critical Care Air Transport Team (CCATT) professionals are extremely multi-tasked due to the nature of the care environment. The AE team is isolated from traditional in-hospital support staff and resources. This austere setting is a significant issue because it can lead to unintentional errors and patient harm. For example, noise generated by the aircraft makes assessment of the patient difficult. A stethoscope and patient monitoring alarms are not effective in this environment. The setting demands healthcare providers utilize visual assessment skills and constantly re-assess the patient. The noise can prevent the healthcare team from recognizing a patient in distress. Application of vICU support may help mitigate this concern and provide another layer of visual assessment to the in-flight healthcare team.

The vICU environment is quiet, calm and controlled and provides an added level of protection to prevent patient safety mishaps and clinical errors.[27] In vICUs, medical professionals collaborate with each other and make care decisions in a non-distracting setting. This allows them to provide continuous consultation to the bedside caregiver. A vICU system would complement the CCATT team by providing continuous visual assessment, patient monitoring and identification of deteriorating patient trends. In addition, vICU capability brings calm to the chaos and can mitigate safety concerns such as patient handoffs.

Improved Patient Handoffs

Research studies of the AE environment identify handoffs, communication and patient preparation as areas of concern regarding patient safety.[28] In the AE setting, patient transfers often happen quickly due to the nature of the austere environment and the aircrew only allowing for a short period of ground time because of potential threats in the area. Multiple patient handoffs performed in rushed, chaotic settings increases the risk for breakdown in communication leading to clinical errors. There are numerous patient handoffs along the transport continuum specifically in a non-garrison environment. For example, patients transfer from point of injury to expeditionary facilities and on to tertiary medical care facilities. These transfers require ground, rotary and fixed wing movement.[29] In one AE research study, a participant revealed a situation where the transferring facility passed a discontinued medication to the receiving medical team. Fortunately the patient did not receive the medication; however, this situation demonstrates a breakdown in the patient handoff process.[30] Implementation of vICU standardized patient handoff protocols mitigates this issue because confirmation and validation of information takes place as the care transfers from one provider to another. The vICU team would also be able to communicate with the ground medical team prior to the patient transport occurring. This pre-flight communication ensures preparation of the patient for flight and makes the handoff process more efficient and safe. vICU capability in the AE setting will enhance the collaborative sharing of information and provide access to essential experienced medical providers leading to better patient outcomes.

Better Patient Outcomes

Decreased ICU Mortality

The Army's Combat Casualty Care Research Program describes a study that showed ICU length of stay and mortality decreased at the Combat Support Hospital in Baghdad as the resources for care improved from no intensivist, to intensivist consult, to an intensivist-directed team.[31] An intensivist is a critical care medical doctor with special training and experience in treating critically ill patients.[32] In 1998 the Leapfrog Group, a non-profit organization aimed at improving patient safety and quality, published research linking the value of critical care intensivists to improved patient outcomes. Scientific evidence suggests intensivists strongly influence quality of care in hospital ICUs because they are familiar with complications that can occur in the ICU and, thus, are better equipped to minimize errors.[33] The ICU physician staffing standard was created by the Leapfrog Group because research showed a 40% reduction in patient mortality when care was managed by a critical care intensivist.[34] Research conducted by Dr. Peter Pronovost links intensivist staffing to a 30% reduction in hospital mortality and a 40% reduction in ICU mortality.[35] An analysis of 2006-2007 data from critically ill patients in 156 hospitals with vICU capability shows a 29% reduction in mortality which translates into an additional 7,233 saved lives.[36] Since its implementation, vICU has proven to be an effective second set of eyes for the monitoring of very ill patients because the concept provides an intensivist-led integrated medical team.

vICUs promote efficient deployment of intensivists and other critical care resources.[37] The data presented here which links decreased mortality rates to care led by intensivists is significant because the specialty trained providers who are part of the Air Force's CCATT are not required to be intensivists. Due to resource constraints in the critical care career field, the Air Force CCATT doctrine allows for other specialty trained providers such as pulmonologist and cardiologists, who may not be board certified in critical care, to transport critically injured patients. These providers receive excellent specialty training and are required to have the skill sets essential to care for critically ill patients in-flight.[38] However, the lack of intensivists to perform the CCATT mission validates why implementation of vICU principles is necessary. Access to intensivists in the AE setting provides direct consultation to in-flight caregivers and can improve patient outcomes. Current AE capability to move critically ill patients to the next level of care contributes to high survival rates. The application of vICU principles into the setting will provide access to intensivists and ensure sustainability of low mortality. vICU will enhance care through implementation of best practices and standardization.

Standardization of Care

Standardization of care decreases variability and provides for best practice implementation in all patient care settings. Research and data prove standardization of ICU care in traditional ICU models can significantly reduce unintentional human error and lead to measurable and significant improvement in patient outcomes.[39] Many interventions incorporated into the healthcare delivery system such as standardized protocols, algorithms and safety checklists focus on patient safety and improving quality. For example, Healthcare Associated

Infections (HAIs), such as ventilator-associated pneumonia (VAP) and sepsis, are leading threats to patient safety taking the lives of thousands of patients each year.[40] This is significant because these types of infections are preventable through use of standardized processes.[41] The Agency for Healthcare Quality and Research identified several tool kits and best practices which standardize delivery of care to prevent HAIs. These tool kits, also known as care bundles, have proven effective in slashing HAI rates and ensuring all patients receive the same level of care.[42] vICU staff ensure bedside caregivers adhere to care bundles and prevent HAIs by validating implementation of the protocol.

The purpose of vICU is to provide improved safety and to enhance outcomes through standardization; however vICU cannot replace bedside clinicians or bedside care.[43] One research study showed remote ICU intervention contributed to ventilator care bundle protocols utilized 95% of the time in mechanically ventilated patients which drove a dramatic reduction in VAP.[44] The same benefit achieved by augmenting the staff with a vICU team of experts enhances the AE setting. For example, medics use flat stretchers to transport injured patients. One of the steps in the VAP bundle includes elevating the head of bed between 30-45 degrees. AE crews have the capability to elevate the patient's head, but in-flight staff may overlook this simple step because of multiple complexities and priorities in the environment due to high volume and acuity of patients. A reminder from vICU staff to elevate the patient's head can thwart risk of the patient acquiring VAP and decrease mortality. vICU staff are capable of identifying trends in patients signaling potential deterioration. This is a critical asset to have in the AE setting because it leads to rapid identification of illnesses such as severe sepsis. Additional surveillance provided by the vICU team along with quick detection of patient instability would direct in-flight crews to initiate immediate treatments such as the sepsis protocol to increase patient's survival.[45] AE environments are isolated from traditional hospital support staff and have limited access to additional levels of expertise. vICU principles can deliver integrated medical care in resource-constrained environments such as AE.

Integrated Medical Care

Optimal Utilization of Resources

The typical vICU team is composed of critical care intensivists, experienced critical care nurses and support staff. vICU allows many different medical disciplines to join together and deliver integrated medical care. Many vICUs are adding additional support staff such as pharmacists, clinical nurse specialists and case managers as a way to optimize scarce resources and further integrate the medical care.[46] The lack of human resources can adversely affect patient outcomes. Research links several studies to show that suboptimal staffing of ICU nurses can lead to increased medication errors, increased risk of pneumonia and re-intubation causing increased complication rates and higher lengths of stay.[47] Throughout the US and in the military, there is an intensivist shortage which has a direct impact on delivery of care. Intensivist care is only available in about 15% of ICUs today.[48] The Leapfrog group fully supports the utilization of vICU principles as a way to overcome staffing gaps and potentially prevent up to 54K deaths per year.[49] An abundance of research indicates the implementation of vICUs to monitor patients at remote locations is delivering integrated medical care by promoting the efficient use of intensivists, critical care nurses and support staff.[50]

vICU capability provides additional nursing staff and expertise to enhance delivery of care at the bedside. This added level of experience can monitor large numbers of patients which are very typical in AE. The addition of vICU nurses potentially allows for CCATT to expand the number and types of patients they are allowed to care for in-flight. There are several different staffing models currently utilized in the vICU arena. One model shows a ratio of 30-40 patients to one tele-ICU nurse.[51] This is significant because it highlights the optimal use of nursing resources and if applied in the AE setting, the opportunity exists to expand the staff-patient ratio which could have an instrumental impact on strategic airlift because it would allow for movement of more critically injured patients if needed and not require the additional personnel or aircraft to do so. The military does not have a plethora of ICU nurses and intensivists but can gain access to these providers through vICU and ensure delivery of integrated medical care.

vICU implementation in the AE platform provides ability to add additional support staff to further enhance care and focus on the needs of the patients. It allows the opportunity to add resources such as flight chaplains, master clinicians and mental health providers incorporating all aspects of care. vICU capability offers a way for a family member to communicate with the patient in-flight enhancing patient-centered care. The AE community must advocate for vICU capability because it brings evidence-based best practices and better patient outcomes through the delivery of integrated medical care. The MHS recognizes the benefit of vICU capability as evident by the development and utilization of vICUs to complement in-garrison care and ensure the delivery of integrated medical care to remote critical care sites. The MHS must act now and consider a fully integrated joint vICU command center. This will allow for the development of a robust capability to deliver integrated critical care to patients anywhere in the world including in AE environments.

Recommendations

Establishment/Development of vICU AE Requirement

As cited in the Joint Concept for Health Services (JCHS), the Capstone Concept for Joint Operation: Joint Force 2020 (CJCS) "requires a globally postured Joint Force to quickly combine capabilities in a future security environment that may be more unpredictable, complex, and potentially dangerous than today's."[52] The JCHS identifies several required capabilities in order to develop a joint force concept which will support Globally Integrated Operations (GIOs). One required capability identified in the JCHS is patient evacuation. This signifies the necessity for the services to work towards a more joint AE platform which integrates unique capabilities and enhances the ERC system. The MODE identifies the vICU capability as a requirement needed to deliver care in future operational environments.[53]

In January 2014, COL Dallas Hack, Director of the Combat Casualty Care Research Program and Janet Harris, Director of Medical Training and Health Information Services established a joint-service focus area work group to guide research in support of virtual critical care capability.[54] This working group guides research initiatives focused on technologies which will enable higher level providers to provide real-time mentorship on complex cases during transport, minimize handoff delays and expedite transport, enable medics to focus on patient care while the vICU system manages data collection, storage and flow along with several other concepts.[55] These initiatives align with the vICU priniciples highlighted in this paper and should be funded, researched and implemented. vICU capability should be an AE requirement because it improves patient safety, leads to better patient outcomes and delivers integrated medical care in austere, isolated settings. The first step in building this requirement is through the development of a joint vICU centralized command center.

Joint vICU Command Center

Current vICU initiatives of the Army, AF, Navy and VA require integration to monitor in-garrison remote ICUs and over time expand the capability to the battlefield and ERCCS. The MHS should develop the capability as an enterprise joint solution. vICU command centers are being utilized to monitor large numbers of patients in multiple states and even being considered for use in natural disasters where there is potential of having mass casualties. For example, NATO leaders are currently collaborating with leaders from Avera Health's telemedicine center in South Dakota to develop a global emergency telemedicine program to provide medical care during major disasters or civil emergencies in countries with very limited resources.[56] The most challenging aspect of building this requirement in the AE setting will potentially be information technology (IT) issues. However, if NASA can provide technology which can monitor patients in space and even treat them if necessary, the MHS must research and push the limits of technology and not allow it to be a barrier to achieving vICU capability. A joint vICU command center utilizes DoD assets efficiently and ensures delivery of safe, quality care. Think about the capabilities provided by vICUs as you prepare to take-off on an AE mission.

Come Fly With Me

Place yourself in the shoes of a CCATT professional. The alert call comes in and requests the need for a CCATT team to respond to Base A. Your CCATT consists of a critical care nurse, physician and a respiratory technician. The team does not have access to an intensivist or additional support staff. As you fight the 140 degree Fahrenheit temperature on the tarmac, your team races to load all the necessary gear onto the C-130 and be wheels up in less than 60 minutes. First part of the mission achieved, you are up in the air within 45 minutes of the alert call! The initial report identifies three patients requiring critical care air transport to a larger medical treatment facility. All three patients require ventilation and have multiple trauma injuries. The pilot alerts your team that the maximum time on the ground to retrieve the patients is 30 minutes due to hostilities in the area. As you arrive at the pick-up point, you quickly notice the patients are not ready for flight. Your heart is racing and all you can think about is the 30 minute window the pilot gave you. Immediately your team divides up and beings to prepare each patient for flight. You spend the entire time prepping the patients by replacing glass chest tube collection containers with ones which are approved for in-flight, changing out intravenous tubing to fit the equipment approved for in-flight and titrating medications to ensure the patients are hemodynamically stable. Patient handoff from the transferring unit is very limited due to the complexity of the environment and the urgency. The only way to get the patients to the aircraft is by ambulance. Your team divides up again and each cares for a patient as you take separate ambulances back to the aircraft. The patient you are caring for has a significant head injury and is sedated. As he is loaded onto the ambulance, he awakens and looks around. You immediately position yourself in front of his face and tell him who you are and that you are moving him to a larger hospital. He nods his head indicating he understands you, squeezes your hand and then goes back to sleep for the remainder of the mission. Time is burning because you have already busted the 30 minute allotted ground time. The aircrew keeps calling to see how much longer. Finally your team arrives at the aircraft which is sitting idle with engines still running. Each patient is quickly loaded onto the aircraft with the assistance of the AE team and aircrew. Your team goes through the pre-flight checklist in their minds to ensure the patients are ready for take-off. You are circling all of your patients to ensure safety measures are in place and everyone and everything is appropriately secured prior to take-off. The thumbs up is given by the physician and finally the C-130 begins to bump and roll down the runway. Once in air, the pilot alerts your team that the aircraft is diverting to another base to pick up three more critically injured patients. Another CCATT will join the flight. Upon arrival at Base B, you are told that your team will have to move your patients from the C-130 to a C-17 and join the other CCATT who is caring for three additional ventilated critically injured. After another transfer of your three patients, the team secures them on the C-17 and prepares for the long flight. Not long after take-off, one of your patients begins to deteriorate. You quickly seek assistance from the AE crew to help support your other two patients while your entire team focuses efforts on the deteriorating patient. The additional CCATT offers assistance but they are also very busy caring for their three critically injured patients. Your team stabilizes the deteriorating patient and continues to deliver care for the next 6 hours. As you are standing at the head of one of the patients, a young Airman approaches you and begins to sob. He doesn't understand why this happened and he proceeds to ask you if his buddy is going to live. You offer him a shoulder to cry on and go to the Lord in prayer with him to ease his pain. You encourage him to stay at the patient's bedside and talk to his buddy. The team finally arrives in Germany to handoff the patients to the next level of care. Your team walks away from the receiving facility and you begin to immediately wonder if you met the patient's needs and if you provided the best care you could in that environment. You wish you had access to additional staff during that flight to help monitor your patients better. You think through the multiple handoffs and hope you didn't miss any critical information. You think about how nice it would have been to have access to a chaplain during the flight who could offer spiritual comfort to the injured and other passengers. You think about how the patients were not ready for the initial flight and about the extra time it took your team to prepare them while in hostile conditions. You pause and take a moment to thank God for keeping you, your team and patients safe. This flight would not replay in your mind a million times and you wouldn't question whether or not you met the needs of the patient if vICU capabilities existed. The reality is vICU capability would have mitigated some of these issues and enhanced the care your team delivered.

Conclusion

Current and future military operational environments require continuous research and innovation to meet mission needs. Continued enhancement of the AE system over the years has led to high survival rates of the wounded, ill and injured. However, changes in the operational environment will demand further innovation of new capabilities. The JCHS indicates patient evacuation is a required capability to support GIOs. The MODE aligns with the JCHS and identifies vICU as a resource to enhance the ERCCS and patient AE. This paper provided an analysis of vICU capabilities and their utility in the AE environment. vICU capabilities improve patient safety, lead to better patient outcomes and deliver integrated medical care. vICU capability is an AE requirement and must be funded, researched, developed and implemented. Combining existing MHS capabilities and resources together to create a joint vICU command center is a priority and will assist in expanding the capability to the battlefield and AE environments.

Notes

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